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ABSTRACT

More than 175 representatives from business, industry, government, and educational institutions gathered to discuss shared concerns about quantitative and problem-solving skills of the work force, linking mathematics education to the health and competitiveness of U.S. business and industry. The primary goals of the conference were to bring the perspectives of business and industry to those concerned with reform in mathematics education, and to seek shared viewpoints that can serve as a collective focus for future collaborative actions. This report includes: (1) an introduction; (2) a brief sketch of the changing U.S. workplace; (3) a concise description of the changing American work force; (4) an essay on the present state of affairs as well as prospects for change within mathematics education; (5) a listing of some of the reported successful collaborative efforts in which business and industry have already supplied schools with talent, enthusiasm, expertise, equipment, and support; (6) an enumeration of ideas for increased corporate advocacy of mathematical reform efforts beyond direct intervention with the professional development of teachers and administrators; (7) a list of working papers that are available upon request from the Mathematical Sciences Education Board; and (8) a list of participants from this Wellspring Symposium. (JJK)

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MATHEMATICS EDUCATION

Wellspring of U.S. Industrial Strength

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REPORT OF A SYMPOSIUM

MATHEMATICAL SCIENCES EDUCATION BOARD

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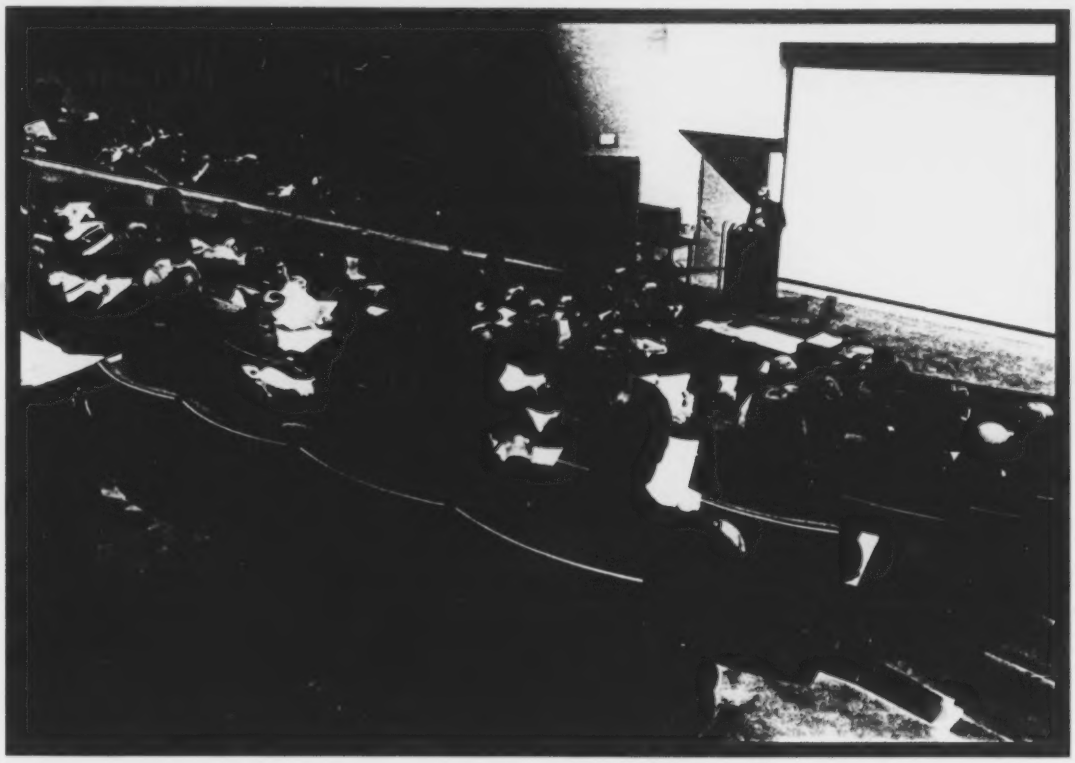

"What has brought us to this meeting is a shared conviction that it is of vital importance to improve the skills of every level of America's work force. Upcoming changes in how mathematics is taught can substantially contribute to that improvement."

John D. Macomber
Export-Import Bank of the United States

On December 15-16, 1988, representatives from business, industry, government, and education gathered to discuss shared concerns about the quantitative and problem-solving skills of the work force, linking mathematics education to the health and competitiveness of business and industry. The occasion was a national symposium, "Mathematics Education: Wellspring of U.S. Industrial Strength," held as one of the inaugural events for the Arnold and Mabel Beckman Center of the National Academies of Sciences and Engineering in Irvine, California.

An important goal of the conference was to bring the perspectives of business and industry to those concerned with reform in mathematics education, and to seek shared viewpoints, a "common ground," to serve as a focus for future collaborative actions. We are especially pleased that 53 corporations were represented at the symposium, which was sponsored by the Mathematical Sciences Education Board.

We hope that everyone interested in improving communication between education and business will find these proceedings interesting and useful.

We wish to express our gratitude to John Macomber, who gave generously of his time and organizational skills to bring this symposium to fruition, and to the Weingart Foundation for the support which made it possible.

Frank Press
President, National Academy of Sciences

Robert M. White
President, National Academy of Engineering

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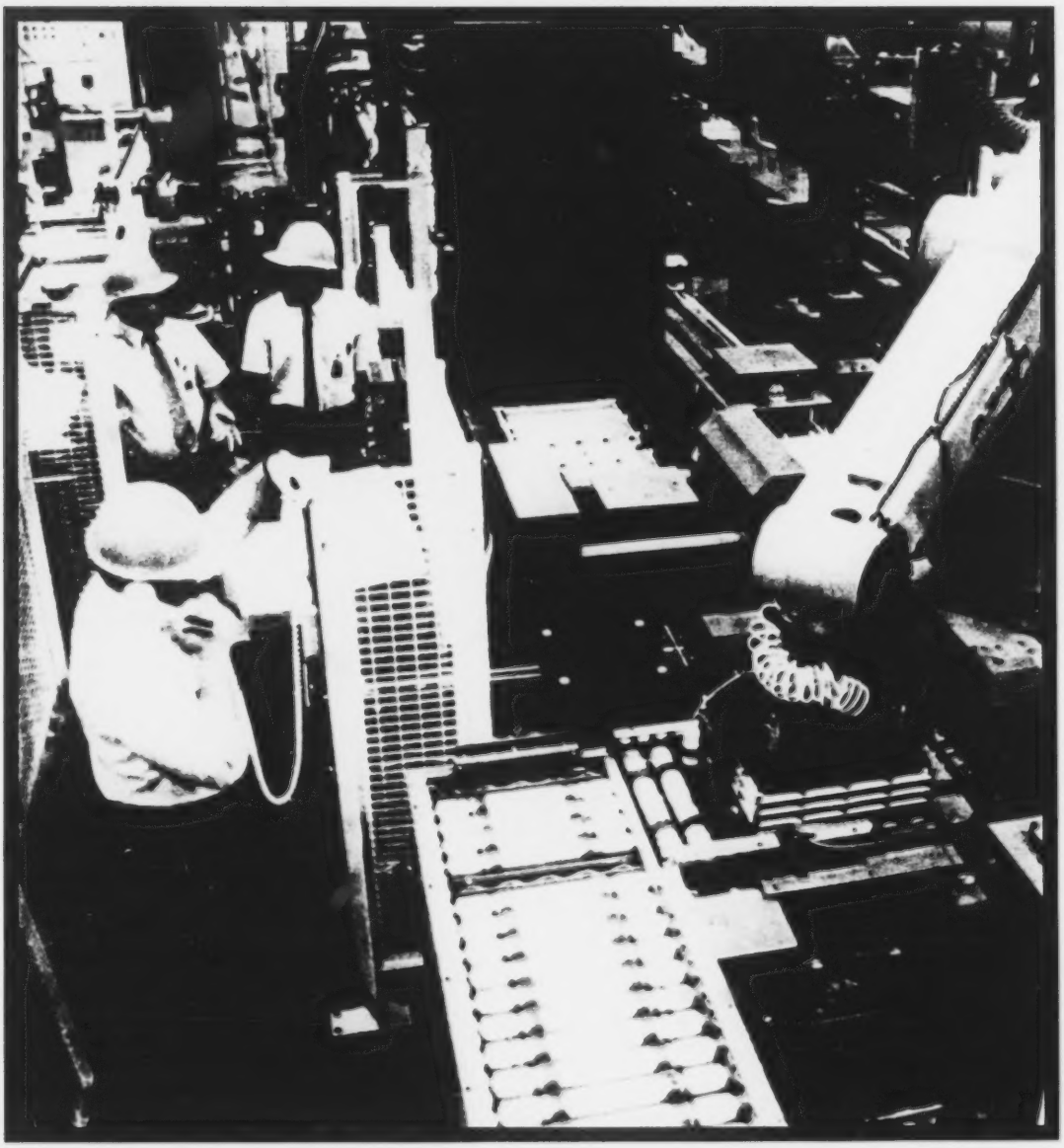
"...Declining educational standards eliminate some applicants from consideration. We estimate that 30 to 40% have limited mathematics and science fundamentals, and that concerns us."

Jim Pilarski
Marriott

"...45% of current military recruits are performing work that would be classified as 'white collar' in civilian life."

Steven Sellman
Department of Defense



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A generation ago, American industry led the world. "Made in the USA" was synonymous with the best. The most reliable, innovative, ingenious, and prestigious products poured from our factories and workshops.

A generation ago, American youth emerged from school with the basic skills needed to make products on mechanical production lines, to keep track of them in offices that ran on paper, and to fund them through financial markets that kept pace with the ticker tape and closed in mid-afternoon. And American workers looked forward to continual increases in a standard of living already the highest in the world.

All that has changed. Today's worldwide, computer-driven, competitive economy demands workers with thinking skills, workers who can deal with computer terminals, automated equipment, and visual data displays; who can make estimates and solve problems; who have a mental "toolkit" of number-managing techniques. Many trades, crafts, and professions are undergoing extensive technological change. Workers now frequently form groups or teams, collaborating rather than working alone. More and more occupations require the ability to understand, communicate, use, and explain concepts and procedures based on mathematical thinking.

Skills for Today's Workplace

In many factories production workers no longer simply wield tools; they also monitor quality, look for problems, repair complex equipment, and plan work loads and procedures. Today's office workers manipulate a variety of high-technology machines and a veritable flood of information.

Even banking, formerly as staid an occupation as one could find, now involves competition in a fast-changing, worldwide, 24-hour marketplace with innumerable possibilities for investment, risk, and return. Bankers, who once might have simply quoted to clients available interest rates, now must understand and communicate the fine points of complex accounts, credit arrangements, futures, and other financial instruments. "When I entered the banking business," Flavio Sa Carvalho of Bank of America stated at the symposium, "our mathematics needs were not very sophisticated. Now, our applications use a variety of complex mathematical functions, and employees must know their purposes, be able to evaluate or check their results, and explain them to the customers."

The rudimentary skills that satisfied the needs of the workplace in the past no longer suffice. The brute figuring that long dominated mathematics education is now done more quickly and reliably by calculators costing less that the book bags in which students carry them. Even complex computations that used to tax experts bent over hand-cranked machines now pour instantly from personal computers that cost one-tenth the price of a car, or from mainframes with computing power unimagined a generation ago.

Workers are less and less expected to carry out mindless, repetitive chores. Instead, they are engaged actively in team problem-solving, talking with their co-workers and seeking mutually acceptable solutions.

"Education must produce people to compete on a worldwide basis."

Gerald Dinneen

Honeywell

Unless educational outcomes change, demographic trends alone will make it difficult for American schools to provide the mathematically competent work force the nation needs.

"The customer for education is the employer in this country, and we're not getting a quality product if we have to spend $25 billion in remedial teaching."

Sam Webster

Texas Instruments

"...Fewer than one applicant in ten is suitable for employment here... we need folks who are willing to use their minds and their hands simultaneously."

Bill Pechstedt

Sanford-Lussier

"All employees will need to apply logical thinking to define problems, collect data, establish facts, and draw valid conclusions."

Judy Whipple

Briggs & Stratton

The "baby bust" cohorts now moving into high school and college are much smaller than those of their older brothers and sisters. For generations, traditional prejudices have encouraged mathematics achievement in only a portion of the population: middle-class white males. Females and non-white minorities — with the exception of Asian-Americans — were seen as both "less capable" of learning mathematics and "needing" it less. Many minority youngsters received — and still receive — inferior instruction. Many women were subtly shunted away from mathematics and toward more "suitable" subjects. Few received any encouragement to persevere when the going got difficult. When the time came to enroll in advanced high school and college mathematics courses, the students who remained in the pipeline were disproportionately white and male.

In the years to come, this traditional source will fall short of filling the nation's quantitative reasoning needs. Between now and the year 2000, only 15 percent of the net new entrants to the work force will be native-born white males. Because white birthrates have held steady, whites constitute a declining portion of the coming generation. In Southern California, for example, non-Anglo "minorities" already account for 53 percent of youth. And women, another mathematically disadvantaged "minority," now constitute a major component of the work force.

Everyone Can Learn Mathematics

"Equalize environments, and performance equalizes," insisted demographer Harold Hodgkinson of the Institute for Educational Leadership, one of the plenary speakers. Conference participants viewed a videotape about the nation's most celebrated proponent of this view, Jaime Escalante, the mathematics teacher at Los Angeles' Garfield High who has seen hundreds of students from a poor Hispanic community through the rigors of Advanced Placement calculus. The only magic in his incredibly successful method is the faith that it will work. He demands that his students bring "ganas"—Spanish for "desire"— and the willingness to work as hard as is necessary to succeed.

"Clearly, we must get mathematical talent from groups that have not supplied large numbers of mathematicians in the past: women, minorities, and the handicapped. This is not an issue of equity but of national priority."

Jaime Oaxaca

Northrop Corporation

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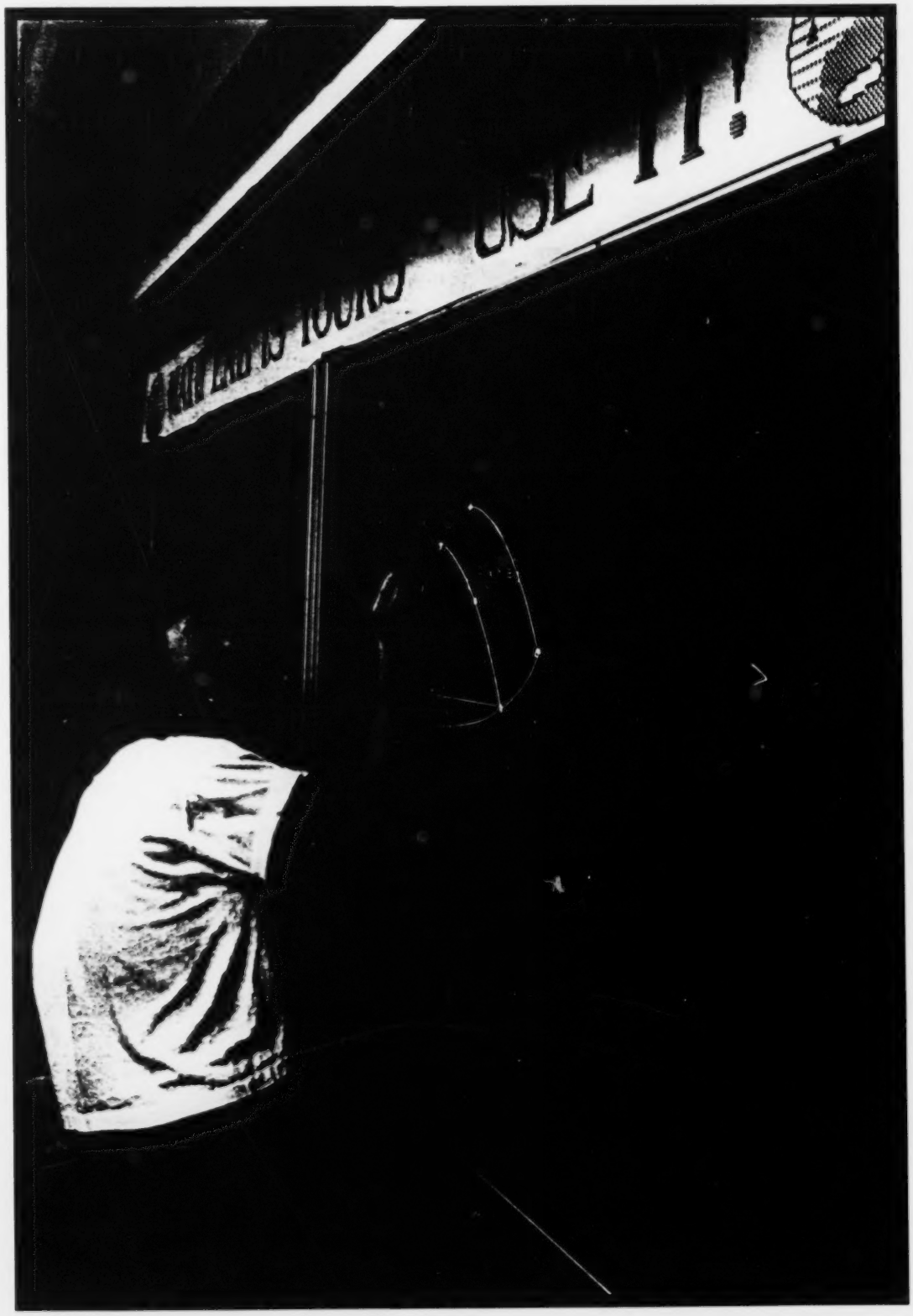
Other than demographic factors, the strongest predictor of earnings nine years after graduation from high school is the number of mathematics courses taken. This finding, reported at the symposium by Clifford Adelman and Nabeel Alsalam of the U.S. Department of Education, comes from a 15-year national study of education and career choices.



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Today we face an impending shortage of the people who will make a modern economy run, women and men who are comfortable with quantitative reasoning and estimation, women and men who are skilled in mathematics.

More importantly, we face overseas competitors whose young people outperform ours and whose economies threaten our industrial leadership.

Much of the business community is awake to the danger. In recent years, companies have experienced shortages of the trained people they need. Many more foresee serious trouble in the years ahead.

Mathematics As a Filter

In the nation's early days, only a handful of children aspired to the few learned professions that required a college education. Most acquired the "three Rs" and then returned full-time to the farm, workshop, or household. The "hard" subjects, including mathematics beyond basic arithmetic, were used as filters to spot and select the ablest few headed for leadership.

Even today, Zalman Usiskin of the University of Chicago said, people assume that "if everybody passes algebra, there must be something wrong with the teacher." This notion of mathematics as a "filter" for talent still pervades our schools, even though the nation now desperately needs to foster, not discourage, every student's mathematics potential.

Persuading America About Mathematics

We cling to attitudes about mathematics that we do not tolerate in any other subject area. We consider an adult who has not done the hard work of mastering the other two "Rs" an illiterate, and a child who can not master them, lazy. We reject the idea that reading is "too boring," "hard," or "not enough fun" for anyone of normal intelligence to learn. But ineptitude at mathematics carries no social stigma.

"Only half of high school kids now think science and mathematics are important for solving today's problems, but 70 percent used to," claimed Jaime Oaxaca of Northrop. "We've got to change these attitudes," insisted Samuel Rankin of Worcester Polytechnic Institute. "We know that TV reaches the people," added Isaac Dvoretzky of Shell Development Company. "We need to tell people 'Math is important, math is doable, math is fun.' We need to put money into this."

Mathematics Matters, In the Classroom and Out

Educators now seek to make reading relevant to children's lives by using texts keyed to their interests and vocabularies, even using newspapers and sports magazines. But the standard mathematics curriculum still presents, virtually unchanged, a body of doctrines dating back to the 15th century. It bears very little relation to the experience of many children, who are given no reason to learn the arcane material they are required to study except that they will need it in the next course.

"The more kids that you get to like mathematics, the stronger tomorrow's work force will be. That's why so many business leaders have come to this conference... "

Harold Hodgkinson
Institute for Educational Leadership

"Educators are putting changes into place. But they need help — they can't change 16,000 school districts alone."

G. Carl Ball

Geo. J. Ball, Inc.

"Our schools are trying to test the quality into the kids. We did that in industry fifteen years ago, and we lost our shirt. We now know that we've got to build in quality."

Sam Webster

Texas Instruments

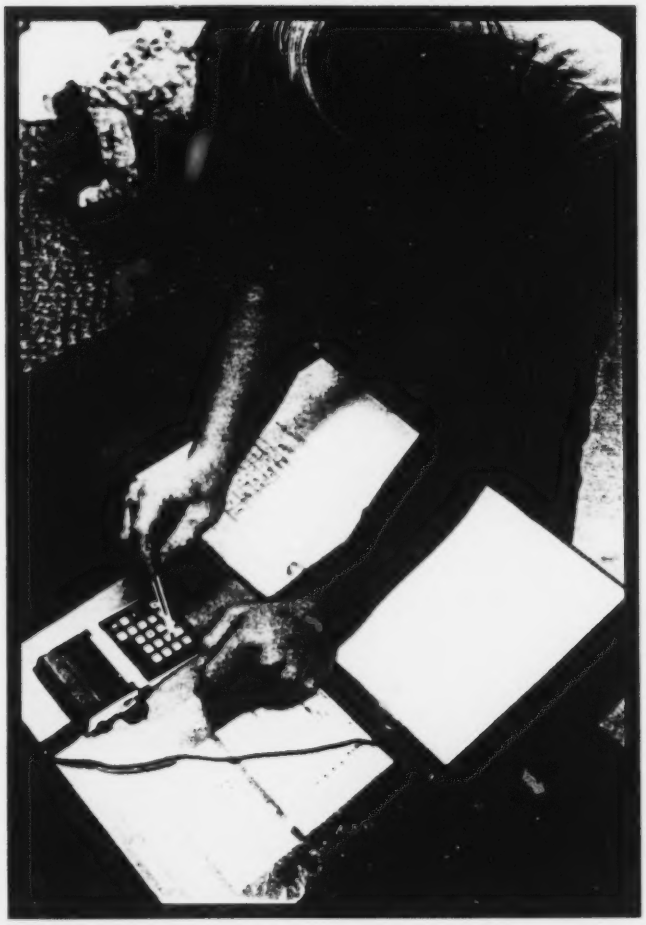
Relevance can make mathematics exciting. Keynote speaker Gerald Dinneen of Honeywell, recalling his two quite different exposures to calculus, noted that in college he took the standard course and found it dry and rather academic. Later, as a World War II meteorologist-in-training, he "got a whole new view." This time, he tackled not a school subject but a skill he could use to save flyers' lives. The same principle will work for today's students, he insisted. "We have to teach mathematics in terms of its applications."

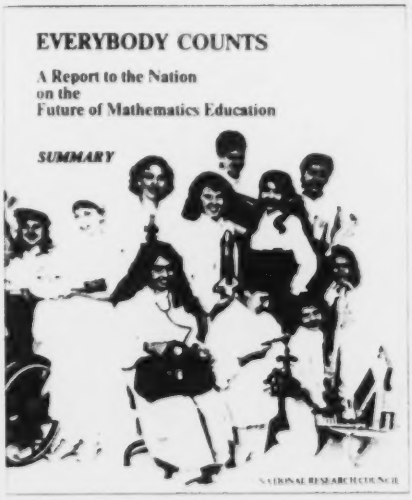
"The challenge to educators," Dinneen said, "is to build the understanding that mathematics includes problem-solving, reading graphs, and interpreting the news." Numbers are the first step in allowing us to make sense of theworld, to understand such concepts as IQ, deficit, batting average, inflation, or annual percentage rate. As consumers or citizens, an understanding of numbers is required to form intelligent opinions about the "bottom line" in any area.

Only by making competence in mathematics as natural, as normal, as unremarkable, and as desirable as the ability to read, will we convince students that learning mathematics is both possible and worthwhile.

Making Mathematics Work for All Students

Traditional, back-to-basics teaching prevails in much of the nation, partially in reaction to curricular experiments of the 1970s. This approach mires youngsters in years of repetitive drill and reliance on formulas and step-by-step procedures. Why not, educators and business people at Wellspring asked, use the problems





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and problem-solving approaches of the workplace to build interest in mathematics? Why not use common workplace tools such as inexpensive calculators to free children so they can use their time to explore mathematics as a method of solving problems? Why not make better use of computer graphics to help children visualize patterns and relationships?

How Should Mathematics Education Change?

In the MSEB report *Everybody Counts* (National Academy Press, 1989), the directions in which precollege mathematics education will change in the coming years are identified as seven transitions:

- The focus of school mathematics is shifting from a dualistic mission — minimal mathematics for the majority, advanced mathematics for a few — to a singular focus on a significant common core of mathematics for all students.
- The teaching of mathematics is shifting from an authoritarian model based on "transmission of knowledge" to a student-centered practice featuring "stimulation of learning."
- Public attitudes about mathematics are shifting from indifference and hostility to recognition of the important role that mathematics plays in today's society.
- The teaching of mathematics is shifting from preoccupation with inculcating routine skills to developing broad-based mathematical power.
- The teaching of mathematics is shifting from emphasis on tools for future courses to greater emphasis on topics that are relevant to students' present and future needs.
- The teaching of mathematics is shifting from primary emphasis on paper-and-pencil calculations to full use of calculators and computers.
- The public perception of mathematics is shifting from that of a fixed body of arbitrary rules to a vigorous, active science of patterns.

The Change Process

"Efforts to bring about lasting change," quoted MSEB Chairman Shirley Hill from a draft of *Everybody Counts*, "must proceed steadily for many years, on many levels simultaneously, with broad involvement of all constituencies at each stage. First must come serious discussion; then compromise and consensus; finally action and change. Even as some groups work to improve curriculum standards, the teaching profession, and assessment practices, other groups must help focus the diverse efforts of business, industry, government, volunteer organizations, and educational enterprises on common objectives."

Education in the U.S. is a distributed responsibility. Educators cannot create reform alone. "Reform in mathematics education will require national consensus for action," Hill pointed out. The grounds for consensus are dialogues, begun by educators and supported by concerned, influential voices outside of education — from parent groups, from government leaders, and especially from business and industry groups such as those present at the Wellspring symposium.

"Our national goal must be to make U.S. mathematics education the best in the world. Nothing less will be adequate to fulfill our aspirations."

Shirley Hill
MSEB

Change has already begun. Across the country, teachers are working toward new and higher standards for mathematics programs; forward-looking business people are working to strengthen mathematics in our schools.

"Many business/education partnerships are successful because they address the isolation of teachers: from each other, from ideas in the field, from what's happening in technology, from change generally, from knowledge about the work force, from industry."

J. Myron Atkin
Stanford University

Members of the corporate community are active at every level, from national advisory boards to individual classrooms. Businesses of all sizes and many industries provide talent, enthusiasm, expertise, advice, equipment, and support to students, teachers, and administrators from the primary grades through graduate school. Cooperation takes forms as varied as the forms of America's corporations and schools, and new ideas continually appear as more companies become involved. Several Wellspring sessions became lively forums for the exchange of ideas that are already working in the companies represented. Corporate participants found much to carry back to their boardrooms, offices, and plants.

The following paragraphs describe some of the successes reported at Wellspring.

Making Service to Education a Company-wide Priority

Throughout America, corporations are encouraging their employees to serve on local councils, school boards, civic groups, and PTAs, and to become involved as school volunteers, witnesses at hearings, and activists in campaigns to improve educational programs and funding. Creating a climate that values such off-the-job participation requires little in the way of organization or investment. Nor does it force employers to favor certain schools or districts over others. But when individuals work as both private citizens and members of firms committed to their communities and to the nation's competitiveness, they have a double motivation that has a powerful local impact.

Digital Equipment Corporation's programs provide an excellent example. As explained by Mark Conway of Digital's Education Investment Review Board, "the company realizes it cannot afford not to be involved in education." Digital currently sponsors initiatives in three broad areas:

- educational infrastructure (for example, teacher and faculty development, or equipment and facilities support);
- direct student support and recognition; and
- local community efforts, employee development, and general education.

Building Educational Partnerships, Collaboratives and Coalitions

Symposium participants, both educators and business people, gave many examples of the benefits associated with relatively permanent, active linkages between schools and local business concerns.

Tommy Ambrose of Battelle Memorial Institute reported that a tax proposal to benefit education died in Seattle because of opposition from the business community. Later, as business people became active in partnerships with local schools, they came to understand much more clearly their own stake in educational excellence. Business support for funding increases grew. At the same time,

"Long-term, sustained, and system-wide changes are now in order. Industry should continue to sound the alarm about how weaknesses in education contribute to our country's decline in economic competitiveness, and should support the national goal of raising the quality of mathematics instruction and student achievement — particularly for underrepresented minorities, women, and individuals with disabilities."

W. Ann Reynolds
The California State University

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"What I really wanted was to have a program that was a vehicle to help young adults understand the importance of their education."

Phyllis Frankfort

Academy of Finance

"I think there's a recognition on the part of our corporation, and of a number of corporations, that you have to be in for the long-term. We've been with our program since 1978."

Harry Greenleaf

Ford Motor Company

educators developed better insight into the nature and needs of local businesses. People who had once seen each other as "on the other side" of tax and school-funding questions came to see that they shared stakes in the same community. As Frank Collea of The California State University put it, these alliances make the people who can "pick up the phone and call the governor" sensitive to the needs of the schools.

The Los Angeles Educational Partnership, supported by hundreds of local businesses, provides a wide variety of services and resources that in four years have reached over 3,000 teachers in 550 schools. It offers small grants that permit teachers to develop creative classroom projects, and then publicizes the results through workshops, a catalog, and an annual event to recognize innovators. It helps inner-city high school mathematics teachers through grants, workshops, and improved planning. It reverses the growing isolation between the public schools and the broader community by training principals to be effective communicators. It supports the Academy of Finance that trains high school students for financial jobs through special courses and summer internships.

The Corridor Partnership for Excellence in Education serves a technology-rich region of Chicago's western suburbs that includes two major national laboratories, Argonne and Fermi, and corporations like AT&T and Amoco. Partnership activities include running a three-year NSF-funded program to teach teachers critical mathematics skills and placing teachers in corporate summer jobs. Along with the Illinois Council of Teachers of Mathematics, the Partnership sponsors a Presidential Awards Program to recognize outstanding teaching. It also took an active role in founding the Illinois Mathematics and Science Academy, a specialized high school.

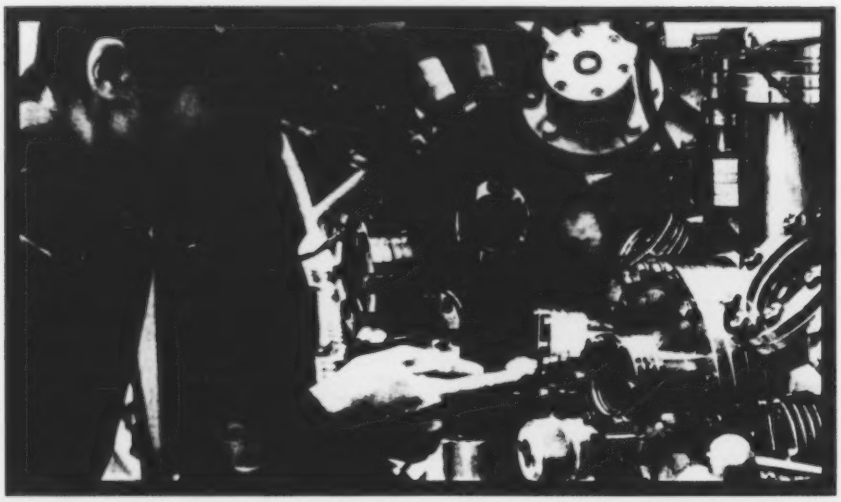
Many partnership projects are underway in cities and towns across the country. More are always needed. Though not all have been uniformly successful, by combining and coordinating local needs, local resources, and local creativity, partnerships have allowed businesses to help education according to their own capacities and priorities.

Supporting National Programs Aimed at Upgrading Mathematics Instruction

Corporate and private foundation support have been key resources in helping develop and implement programs whose scope extends beyond local concerns. The Amoco Foundation, for example, has provided $6.4 million since 1983 to the University of Chicago School Mathematics Project, a 6-year effort to develop a comprehensive new curriculum in mathematics for all students from kindergarten through 12th grade. Joining in this effort have been the Carnegie Corporation of New York, Citicorp/Citibank, Ford Motor Company, the General Electric Foundation, the GTE Foundation, and the National Science Foundation. Other Amoco grantees include the National Action Council for Minorities in Engineering and the Principals' Scholars Program.

Informing Educators About the Workplace

Teaching mathematics through applications requires a kind of hands-on knowledge of workplace conditions that most teachers lack but that the business community has in abundance.



Faculty member Mare Taagepera of the University of California, Irvine (UCI) reported that representatives of local schools and representatives of local corporations including Chevron, Ford Aerospace, McDonnell Douglas Astronautics, and a number of smaller companies, meet regularly as the UCI Science Education Advisory Board. Together they designed "Modern Technology," a college course to keep teachers abreast of technological change. Other projects include one-day research update clinics and summer-long science institutes for teachers.

Real-world problems from local businesses can make challenging and illuminating class projects and assignments, as shown by successful courses at the Claremont colleges, Clemson University, Oklahoma State University, and Rensselaer Polytechnic Institute.

Corporate advice can also help colleges decide which programs to offer. Symposium participant Samuel Webster of Texas Instruments reported that a Texas junior college scrapped plans for a program to train robotic repair technicians, "a job of the future," when informed by his company that "we only employ about ten worldwide."

Giving Teachers and Students Opportunities for Workplace Experiences

Experiences can range from one-day plant visits to ongoing employment programs. Work-study and internship programs can keep young people in the mathematics "pipeline" by showing the opportunities awaiting the mathematically trained. Summer jobs for teachers, involving serious work commensurate with their professional status, can keep able people in the classroom by ending their intellectual isolation, enriching their understanding, and enhancing their income. Such programs, however, must be carefully designed to keep good teachers teaching and not to "cream" the most able into better-paying corporate jobs. Up to now, Howard Adams of the National Consortium for Graduate Degrees for Minorities in Engineering (GEM) noted, "industry seems determined to eat its own seed corn" by luring fine teachers permanently out of the classroom.

Providing Lecturers and Equipment to Schools and Colleges

Although companies, especially those in high-technology sectors, have long provided lecturers, visiting researchers, and equipment to colleges and universities, they have been slow to recognize the value of doing something similar in the schools. William Linder-Scholer of Cray Research reported that Cray now encourages employee role models, especially women and minorities, to speak with school groups about the mathematics needed at work. Tandy Corporation, according to William D. Gattis, provides schools with computers. Many other companies make similar contributions, both financial and in-kind, ranging from science fair judges to laboratory equipment.

Encouraging Retirees to Consider a Second Career as Teachers

At centers from San Diego to Glassboro, the National Executive Service Corps (NESC) is training and placing military and corporate retirees as high school mathematics and science teachers, tapping a huge but almost untouched national resource, the 50,000 scientists and engineers who retire each year. Although only a few years old, the program already has "graduates" sharing their maturity and practical experience with students in North Carolina, California, Connecticut, and New York classrooms.

Another NESC program recruits volunteer scientists and mathematicians to aid teachers. Reports of success have already come from White Plains, New York; Camden, New Jersey; and Baltimore, Maryland, according to Dorothy Windhorst, a Pfizer executive currently seconded to the NESC.

For companies across America, efforts like these represent, in the words of Mark Conway of Digital Equipment, "little more than common sense." He sees a "new level of commitment, and a sense of urgency regarding the importance of education" throughout his company.

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Get more involved!

- *Understand how and why mathematics education needs to change*
- *Step up your local programs; communicate headquarters priorities to local managers*
- *Expand your corporate educational portfolio to include national and regional, as well as local, activities*
- *Sustain involvement over the long term*

Get others involved!

- *Carry the message of your activities to other firms; share information about what works*
- *Analyze your work force needs; communicate these needs to educators*
- *Participate in local and regional coalitions and partnerships; recruit other firms*

Help educators persuade the nation!

- *Link corporate efforts to the national reform agenda; voice your support for reform to policymakers at all levels*
- *Support local and national public information efforts*

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Although current corporate involvement is extensive, the continuing and pressing need to improve mathematics education in the nation's schools and colleges caused participants to ask "what more can employers do?"

Discussions toward the close of the symposium provided directions in which answers may be found.

"...We must ally corporate America to the reform effort underway in mathematics education. We don't want reforms to stall as public attention wanes or shifts..."

John Walsh

Boeing Military Airplanes

Stepping Up Local Involvement

As John D. Macomber succinctly expressed it in his closing address, "The first priority is to extend corporate involvement at the local level." The objective of reform efforts is to make sure that every mathematics class in the nation, from kindergarten on, better reflects both what educators know about teaching and learning mathematics, and what employers and employees know about the world of work. Progress will be based, in large part, on local collaboration and support for teachers and administrators from business and industry.

The primary role of industry should be to encourage and support the efforts of the teaching profession and school administrators, rather than to attempt direct intervention in the professional development of teachers and administration of schools. At the same time, the corporate community needs to be assured that its collective efforts add up to something, and that mutually consistent directions are being pursued by educators nationwide.

Changing Public Attitudes

Another key to increasing interest and success in mathematics is fundamental change in public attitudes. It was pointed out in discussion that campaigns to change public attitudes can be conducted locally as well as nationally, and that public information efforts can build on established corporate media campaigns in many useful and effective ways.

Corporate America can have an enormous influence, whether by active example or by omission, on the value messages that reach children and their parents through the media— particularly through television. As Harvey Long of IBM pointed out, television programs that ridicule serious students as "nerds" have at least the tacit approval of their corporate sponsors. The same can be said of programs in which adults project the "I was never any good at math" attitude, thereby suggesting to young people that it does not matter whether or not they learn mathematics. If those values are seen as threats to the health of the nation's economy, corporate leaders have the power to change these insistent and cumulatively negative messages.

"The piece that's missing is the translation of the needs of business and industry to the education community."

William Gattis

Tandy Corporation

Influencing Public Policy

Individual business and industrial organizations, as well as business associations, need to be made aware of the urgent need to revitalize mathematics education and must be stimulated to take action.

As Thomas Sciance of E.I. du Pont de Nemours & Company expressed it: "One thing we hope will come out of meetings like this is a way of persuading some of the national business organizations that already exist to take an interest in mathematics education, and to bring these facts to the attention of the right people and actually influence policy."

Meeting with the President

A proposal advanced at one session was to organize a meeting of corporate leaders with President Bush, to persuade him as the "Education President" to join forces in changing public attitudes that now deprive our nation of so much of its potential intellectual power. It was noted that the greatest challenge is to change negative attitudes about mathematics.

Reaching Local Management

The value of reaching larger corporations at both headquarters and local levels was also a topic of discussion. Some participants were of the opinion that if one involved the top hierarchy of a corporation, it would likely result in involvement being encouraged at all of the company's local facilities. Others argued that, in practice, such impacts were unlikely to spread beyond headquarters, and that corporations which have enlightened leadership policies about education must devote far more effort to ensuring that these understandings reach local managers.

Sustaining Corporate Involvement

A number of participants emphasized the importance of sustaining corporate educational activities over relatively long periods of time. There are several factors, ranging from perceived need to maximize short-term returns to fear of leveraged buyouts, that work in concert to limit corporate capacity to sustain attention to matters not impacting the immediate bottom line. Participants suggested that corporate attitudes will have to be changed, as will those of the general public, if sustained corporate attention to education is to be achieved. Changing corporate attitudes will require strong national leadership.

Extending Existing Activities

Symposium participants emphasized that the highest priorities for future corporate involvement should be: (1) extension of activities to more classrooms and schools, to more companies, to more geographical areas; and, (2) coordination of activities nationwide to increase overall effectiveness. Planning will need greater emphasis than the continual search for new and different mechanisms for industry/school cooperation.

Sharing Information

The need to share information about education reform efforts, and to learn from experiences in involvement and partnership, were mentioned by a number of participants. One example discussed was that of the Triangle Coalition for Science and Technology Education, a network of national, regional, and local groups from business, science and engineering, and education. The point was made that a more specialized resource, focused on mathematics education reform efforts, is undoubtedly needed. Mark Conway of Digital Equipment Corporation mentioned that one way the symposium had been helpful was in acquainting him with a variety of useful projects in mathematics education.

Informing Educators about Workplace Needs

Corporate links to mathematics education have never been strong. Consequently, many mathematics educators need opportunities to learn more about mathematical thinking in the workplace. Often this effort first involves getting employers themselves to better understand exactly what their work force needs are. Quantitative and problem-solving skills, along with literacy, are most often cited by employers as crucial in today's — and tomorrow's — workplace, but often little thought has gone into understanding precisely what new employees should know and be able to do.

Companies in many local settings are involved in conveying to educators a sense of the workplace and their work force needs, whether by developing work-related problem sets with teachers, or by bringing teachers or students into the workplace as summer interns. However, at the national level it is vital that business and industry also spearhead an effort to come to better understandings of the work force needs of major employing sectors, and to convey those understandings to educational leaders.

Implementing a National Game Plan

Symposium participants repeatedly emphasized that the unity of purpose and coordinated action seen in the current reform effort in U.S. mathematics education present an unusual opportunity to the corporate community — an opportunity to link corporate activities to the reform movement, thereby assuring that human and dollar resources are used efficiently with significant long-term impact.

In her remarks near the beginning of the symposium, MSEB Chairman Shirley Hill described the national strategy being employed by the mathematics education community as "national goals with local implementation." William Dennis of the National Federation of Independent Business later remarked, "We need to think nationally and act locally."

The Wellspring symposium conveyed a sense of the abundance of opportunities for collaboration between the corporate and education sectors, many of which are being turned into realities at local and regional levels. But beyond these efforts, there was a feeling of something missing: a mechanism for national leadership and coordination specifically designed to help corporations fit their mathematics education activities into a larger national strategy.

In his closing remarks, John Macomber proposed the formation of a Corporate Council for Mathematics Education under the auspices of the National Research Council:

"And, finally, for some of you I have a real challenge. Join us in our effort to provide national leadership for corporate involvement in improving mathematics education. In the next few months we should form a Corporate Council for Mathematics Education, to enlist and coordinate business and industry support at all levels nationwide..."

"Join us...to provide leadership for corporate involvement in improving mathematics education... to enlist and coordinate business and industry support at all levels nationwide."

John D. Macomber

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What the Corporate Community is Doing

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Involvement in Education as a Business Decision
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Keeping Talented Youth in the Technical Pipeline
Clifford Adelman and Nabeel Alsalam
U. S. Department of Education
Miguel Macias
National Action Council for Minorities in Engineering
Barbara Scott Nelson
The Ford Foundation
Greg Simoncini
Phillips Academy

What More Can Employers Do?

National Oversight and Leadership
George E. Brown, Jr.
U.S. House of Representatives (D-CA)

State/Local Coalitions and Partnerships
Gail A. Digate
Corridor Partnership for Excellence in Education

Communicating Employers' Work Force Needs
Marina Buhler Miko
Higher Education Strategic Planning Institute

Sharing Information About Corporate Activities
John Fowler
Triangle Coalition for Science and Technology Education

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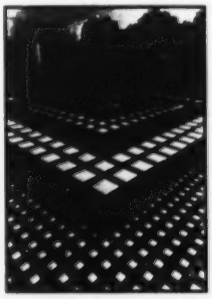

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